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organic remains which I saw were some fragments of *Lepidodendron* from the strata immediately overlying the coal bed at the Arroio dos Ratos mine. These were much compressed and broken, but the generic characters were still clearly recognizable, and they are sufficient to establish the Paleozoic age of the beds. Beyond this I can only give it as my decided opinion that the coal rocks are of the Carboniferous period, and probably coeval with the Santa Catharina coal formations.

The question arises whether the coal beds were laid down in one sheet, which was subsequently folded as the ridges were formed, and then denuded over their tops; or whether the ridges already existed when the coal beds were formed, the latter having been deposited in the valleys between them? It appears to me that the ridges were partly raised before the coal beds were formed; that the latter were first laid down in the hollows, but gradually the upper beds extended over the granite hills. Subsequently the ridges were raised still higher, and the sedimentary rocks were denuded away from the granite on their summits. The original continuity of the beds appears to be proven by the general conformity of the sections in the three basins which I have described; but the inclination of the coal rocks is everywhere much less than that of the sides of the granite ridges.

Another question is important in an economical sense; Are there other beds of coal below that which is now worked in the Arroio dos Ratos mine? I think not. It seems certain that the section in this basin is the same as that at Dous Passaros, where the coal rocks lie directly on the granite, and no trace is seen of another coal bed below the iron-ore layer. As it appears that this latter bed has been cut in excavations made below the coal, I believe that further borings would only show layers of sandstone followed, at no great depth, by the granite.

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## ON THE SHELLS OF THE COLORADO DESERT AND THE REGION FARTHER EAST.<sup>1</sup>

BY ROBERT E.. C. STEARNS.

### PART I.—THE PHYSAS OF INDIO.

**A**BOUT four years ago I called attention to certain specimens of fossil shells contained in a lump of earth taken from the

<sup>1</sup> This paper was read before the California Academy of Sciences, June 5, 1883. It may be regarded as supplementary to my "Remarks on Fossil Shells from the Colorado desert," published in the *NATURALIST*, Vol. XIII, March, 1879.

bottom of a well forty-five to forty-seven feet deep, at Walter's station on the Southern Pacific railroad, the level of the Colorado desert at that point being 195.54 feet below that of the ocean.

The specimen of earth was collected by Professor Davidson, who kindly submitted it for my investigation. Recently on his return from the Transit of Venus Observation station in New Mexico, he made a further examination in the desert, at Indio, a station on the same line of railroad, 109 miles north-westerly from Yuma (on the Colorado river), and thirteen miles this side, *i. e.*, northerly from Walter's,<sup>1</sup> where the previous collection was made. This new material is from the surface, at a point where the line of the road is twenty-seven feet below the level of the sea at low water.

The soil is of the same general character as that from the well, an exceedingly fine sediment, friable and readily separating in water. The Indio sample contains numerous micaceous particles, in this respect differing from the specimen of earth from Walter's station.

The molluscan forms include fragments of the valves of the common fresh-water mussel of the region, *Anodonta californiensis*, also the gasteropods, *Amnicola longinqua*, *Tryonia protea* (two



FIG. 1.—*Tryonia protea*.

varieties only, one smooth the other finely cancellated), also a collection of between eighty and ninety of the pond-snails, *Physa*, including perfect and imperfect specimens.

This portion of the collection is of special interest, as it furnishes a most satisfactory, because continuous, varietal chain connecting certain forms heretofore generally regarded as species, of which I have, on various occasions, expressed the opinion as be-

<sup>1</sup> These places are in San Diego county, along the western flank and nearly at the base of the San Bernardino mountains, which traverses the region diagonally in a north-westerly and south-easterly direction, from the northerly boundary of the State nearly to its southerly line, following the axis of the range, a length of about 150 miles.

ing at most but more or less colonial or local varieties of the same general form.

The species of *Physa* heretofore credited to the southern portion of California are *P. humerosa* and *P. virgata*. Binney<sup>1</sup> gives



FIG. 2.—*Physa humerosa* Gould. Natural size.

the localities of the former as "Colorado desert, Cal.; Pecos river," but at what point on said river is not stated. Cooper<sup>2</sup> credits it to "Pecos river, Texas," but why Texas I have been unable to discover, as the Pecos is a stream several hundred miles in length, extending from its tributary sources in the southerly subranges and lower flanks of the Rocky mountains throughout a large area in New Mexico, and nearly to the southerly line of Colorado Territory before reaching Texas; the omission or lack of precision is unfortunate. This is evident when it is seen that the Pecos is the main tributary of the Rio Grande, whose waters are the resulting accumulation of a drainage area farther east than any we have heretofore considered, extending in fact, in part, farther east than the easterly flank or foothills of the Rocky mountains, and discharging on the easterly or Atlantic side of the continent into the Gulf of Mexico. The occurrence of any of these forms which have been regarded as belonging to the fauna of the Pacific coast regions, with which we are familiar and to which your attention has been heretofore directed, within the area of more *easterly* faunal domains, has a most important significance as related to the variation or identity of species, and still more in its bearing upon the relation of faunal characteristics and specific characters to environmental conditions.

Still further to the east we have the Colorado of the east, or the Colorado of Texas (or little Colorado) as it is variously called, which also empties into the Gulf of Mexico, and drains an area estimated at 38,000 square miles, extending north-westerly toward the drainage basin of the Rio Pecos to the table plains of New Mexico and Texas, the Staked Plain so-called, or Llano

<sup>1</sup> L. and F. W. Shells of N. A.

<sup>2</sup> Geographical Catalogue, April, 1867, species 368, 369.

Estacado of the Spanish, a nearly barren waste whose general level is from 3000 to 4000 feet above that of the sea, its main features otherwise being like those of the great interior desert to the north-west, and that of the Colorado basin<sup>1</sup> in California.

*Physa virgata* Gld., is attributed by Binney<sup>2</sup> to Los Angeles, where I found it abundant in the basin of the fountain in the plaza near the Pico House, opposite the old parish church; also near San Diego and in the Gila river in Arizona, exact locality not stated.

Cooper<sup>3</sup> also gives its range as "Mojavé river to Gila river," on what authority as to Mojavé river and region I do not know.

As above suggested a glance at the map is necessary to obtain a clear idea of the extent of the area incidental to this discussion. San Diego county alone includes an area of over 15,000 square miles, and extends from the Pacific ocean to the Colorado river, its southerly boundary extending easterly along the Mexican line 175 miles to Fort Yuma, on the Colorado.

<sup>1</sup> The drainage area of the various basins, within which either of the West American forms of fresh-water Mollusca occur, to which reference has been made in this or previous papers of mine relating to the distribution of such forms, may be briefly stated (in square miles) as follows:

Columbia river.....	298,000
Colorado " .....	257,000
Rio Grande " .....	240,000

This of course includes that of its tributary the Rio Pecos, the same as the Colorado includes the Gila, etc.

Of the lesser basins the Sacramento is figured at 31,503, and the San Joaquin at 24,710 square miles, including the mountain slopes which descend to and merge in said plains; these are the figures kindly furnished me by Wm. H. Hall, Esq., the State engineer. From the Coast Survey department, Professor Davidson informs me that the great valley, including for example Napa and Alameda counties, contains 506.50 square miles; the two main drainage systems of the Sacramento and the San Joaquin and Tulare are nearly evenly divided.

It is not unlikely that the drainage of the California region, as related to those forms of animal life herein discussed, may reach the larger figures I have submitted, which added together make a total of over 56,000 square miles west of the crest line of the Sierra Nevada range, and if this total be added to the drainage areas of the exterior basins or regions above recited, show a grand total of 851,000 square miles, to say nothing of the vast area farther to the north not included within the figures or limits of the Columbia River basin.

Omitting the Rio Grande area, which may be considered by some as at present debatable ground, we have left 611,000 square miles, an area so vast as to require the examination of a map in order to be appreciated.

<sup>2</sup> L. and F. W. Shells of N. A., p. 93.

<sup>3</sup> Geographical Catalogue.

The typical form of *Physa humerosa* may be stated in brief as being rather short and stumpy, the upper part of the last or basal whorl flattened or tabulated, with a small, low, slightly elevated apex, as a whole presenting a somewhat obtuse triangular aspect. Its next of kin, geographically, is *P. virgata*, which is a rather elongated form with an elevated spire.

Now the Indio lot exhibits some examples more triangular in general outline and more tabulated or flattened above than the typical or even ordinary *humerosa*, and variation also in the direction of *virgata*, and still other specimens passing, by way of said species, to still greater elongation and elevation of the spire. Within these extremes of variation we have also a connecting link with the widely distributed and abundant *P. heterostropha*, which Binney<sup>1</sup> credits to Utah lake on the testimony of Capt. Burton's specimens in the Smithsonian collection, which brings that species within the drainage area of the Colorado river, and indicates the path of migration to the desert region wherein Indio and Walter's stations are situated.

Besides the forms and their varieties as above, we have extreme variation amounting to distortion in several instances—all pointing to this (Indio) locality as a most interesting region wherein to study the phenomena of variation in this class of shells.

In my recent paper on the Fresh-water Mussels, etc.,<sup>2</sup> more particularly in that portion on the circumboreal distribution of certain fresh-water gasteropods, I refer to the American *P. heterostropha* as representing the European *P. fontinalis*; the connection or intimacy of these various alleged species, as fresh material from new localities comes to hand, is evidently of great importance as throwing additional light on geographical distribution and physico-geographical conditions.

While Mr. Binney regards many of the species heretofore described as synonyms, and so places them in the work to which I have referred; he often gives but a single figure to illustrate such species as he regards as valid, and which include certain of these synonyms.

The variability of the pond snails is so excessive that it is quite impossible to present the protean facies they display with-

<sup>1</sup> L. and F. W. Shells of N. A., p. 89.

<sup>2</sup> Nov. 20, 1882, Proc. Cal. Acad. Sciences, "On the History and Distribution of the Fresh-water Mussels," &c., &c.

out numerous figures. In nearly every colony, however isolated, where individuals were at all numerous, I have rarely, if ever, found so persistent adherence to a single form as to admit of proper illustration by a single figure.

PART II.—*ANODONTA CALIFORNIENSIS* IN A NEW LOCALITY.

By the same mail which brought me the Indio parcel and Professor Davidson's letter relating thereto, a note came to hand from Mr. Joseph F. James, custodian of the Cincinnati Society of Natural History, who, after reading my recent paper on the "Fresh-water Mussels," etc., very kindly informed me that in June, 1880, he collected "*Anodonta californiensis* in the little

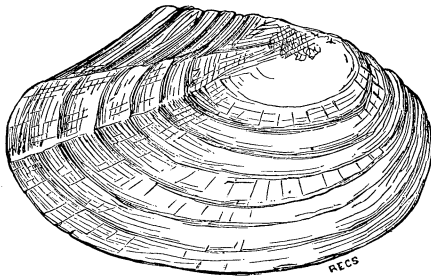


FIG. 3.—*Anodonta californiensis* Lea.

Santa Cruz river, just outside of Tucson, Arizona." This item of information gives quite an extension toward the east and south-east of the territory before known as tenanted by *californiensis*. The little Santa Cruz is a confluent of the Gila, and enters the latter at Gila Bend. The Gila is a confluent of the Colorado, joining the latter near Yuma. Tucson is about 250 miles east of Yuma, and following the course of the Gila to the mouth of the little Santa Cruz, thence southerly to Tucson, represents a sub-drainage area of which the length is much greater.

An examination of a map of the region easterly and south-easterly of the main stream of the Colorado and of the drainage of the Gila, will enable one to take in at a glance the many streams which are tributary to and finally merge in the Gila and still later or afterward in the Colorado, which, together with the important fact furnished by Mr. James, warrant the inference that an exploration of the ramifications of the water channels of the region included within their net-work, will show that the domain

of this *Anodonta* extends over a vast area, embracing thousands of square miles of which as yet but little is known.

Every item bearing upon the geographical distribution herein referred to, and more elaborately discussed in my recent paper,<sup>1</sup> indicates the mountain lakes as the sources from whence the species have migrated, and point also to their descent from northerly regions as well as from higher altitudes, and also contribute additional testimony as to the antiquity of these widely-spread though inferior forms of animal life.

Admitting the presence of *Physa humerosa* within the drainage of the Pecos, to which we find it accredited, and considering the new locality for *Anodonta californiensis* which Mr. James has given us, and the fact that the *humerosa* form of *Physa* seems to be (geographically within the southerly portion of our West American or occidental *Anodon* province) a pretty constant companion with said fresh-water mussel, we are encouraged to hope that we may find this aspect of the general West American form of *Anodon* represented within such drainage areas as contain or are inhabited by the *Physa*.

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## REVIEW OF REPORT C<sub>4</sub>, SECOND GEOLOGICAL SURVEY OF PENNSYLVANIA.

BY DR. PERSIFOR FRAZER.<sup>2</sup>

THIS new volume of the publications of the Pennsylvania Survey deserves much more than a passing notice, from the eminence of its editor and the number and nature of the criticisms which it challenges.

As to the latter they should commence with the title page, where, as will sufficiently appear further on, Mr. Hall would certainly repudiate the claim of having added materially to the structural geology of Chester county; indeed he has done so both personally to the writer and in his pages (54 to 64) of this volume. It will be advisable to consider his part of the volume first, but before doing so the writer wishes to protest against the heading of page 1, which should have been altered to conform to the title page. The

<sup>1</sup> On the History and Distribution of the Fresh-water Mussels, &c., &c. Proc. Cal. Acad., Nov. 20, 1882.

<sup>2</sup> C<sub>4</sub>. Second Geological Survey of Pennsylvania. "The Geology of Chester County after the Surveys of H. D. Rogers, Persifor Frazer and Charles E. Hall. Edited by J. P. Lesley. Harrisburg, 1883."